Effects of Highway Capacity Changes on Energy Use and the Environment

A Minority Report to the Transportation Research Board

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Abstract

Current traffic and emission models need expeditious improvement and substantially higher levels of research, data collection, development, and dissemination of best practices techniques. However, significant and steady improvement in operational regional models for evaluating the likely emission, system performance, travel behavior, and development impacts of changes in highway capacity, pricing, and policy is possible in both the short and mid-term to meet current regulatory requirements. State-of-the-art modeling methods, if applied with common sense (e.g. considering likely effects of transportation capacity on land development patterns), are adequate to judge the likely direction and approximate magnitude of regionally significant highway capacity additions in transportation plans.

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Summary

The Transportation Research Board (TRB) committee charged with evaluating the effects of added highway capacity on the environment and energy use has reviewed extensive literature and conducted numerous meetings in pursuit of consensus. While I concur with many of the report's findings, some of its findings and much of its tone are based on judgments or opinions I must reject, based on my eighteen years of experience as a transportation planning engineer and modeling professional. This TRB report is correct in identifying the need for improvement of our analysis tools, but it errs by asserting that we cannot adapt our analysis tools to meet current regulatory requirements without substantial delay. The problem is not a lack of good science to support analysis, but institutional resistance to the use of good science in transportation analysis that would challenge entrenched and powerful pro-highway expansion interests. One might hope that this TRB report will contribute to increased investment in improved analysis and transportation/environmental monitoring systems. It would be unfortunate if the report's conclusions are misread as an excuse for inaction, regulatory roll-back, and a resurgence of business-as-usual highway policies on the basis that we just do not know what the future might bring. Citizens need no experts to know that one does not cure obesity by loosening one's belt nor cure traffic-related problems by simply expanding highways.

Readers of this report should consider two important closely related reports issued in 1994 by high level study commissions in the United Kingdom. These considered a wider range of evidence and drew conclusions and judgments that contrast with this TRB report and which are generally more consistent with this minority report. The Standing Advisory Committee on Trunk Road Assessment (SACTRA) report, *Trunk Roads and the Generation of Traffic*, **(1)** focuses specifically on the strong evidence that highway capacity expansion spurs increased motor vehicle travel demand. The Royal Commission on Environmental Pollution report, *Transport and the Environment*, **(2)** gives an overview of the broader challenge of making transportation more sustainable, including extensive discussion and recommendations regarding the role of road investment in contributing to environmental degradation.

This TRB report does not give appropriate consideration to evidence related to the effects on energy use and the environment caused by a *reduction* of highway capacity -- for example the effects of traffic calming and traffic cells -- although such evidence is highly relevant to the issue at hand. While asserting that transportation pricing strategies are more important than changes in highway capacity in determining environmental performance, this TRB report gives only limited consideration to evidence from outside the United States which might isolate the effects of highway capacity changes from the effects of transport pricing, levels of public transportation provision, and alternative land use and urban design patterns. Excluding this evidence, and in a tone that appears to subtly play to one side of current contentious domestic policy debates, the report concludes that our state of knowledge is insufficient to evaluate the effects of added highway capacity to support current federal environmental regulations.

It is intellectually inconsistent for the report to argue that, on the one hand, current models cannot evaluate the effects of changes in highway capacity on the environment while, on the other hand, asserting that alternative strategies, such as time-of-day tolls, will have known and larger effects on air pollution emissions. If we lack the ability to develop reasoned estimates of likely effects of changes in highway capacity, we would likely also lack the ability to estimate the effects of changes in pricing, technology, or other system attributes. However, the report's lead finding in the Executive Summary concludes that, *"analytic methods in use are not adequate for addressing current regulatory requirements* [to assess the effects of added highway capacity on air quality]. *The accuracy implied by the interim conformity regulations issued by EPA, in particular, exceeds current modeling capabilities...In sum, the current regulatory requirements demand a level of analytical precision beyond the current state of the art in modeling.*"

Current traffic and emission models need expeditious improvement and substantially higher levels of research, data collection, development, and dissemination of best practices techniques. However, significant and steady improvement in operational regional models for evaluating the likely emission, system performance, travel behavior, and development impacts of changes in highway capacity, pricing, and policy is possible in both the short and mid-term to meet current regulatory requirements. State-of-the-art modeling methods, if applied with common sense (e.g. considering likely effects of transportation capacity on land development patterns), are adequate to judge the likely direction and approximate magnitude of regionally significant highway capacity additions in transportation plans.

Unfortunately, in the five years since passage of the 1990 Clean Air Act Amendments (CAA), metropolitan planning organizations (MPOs) that are typically responsible for evaluating transportation conformity have made only slow progress in improving their analytic tools to respond to new policy requirements. Ironically, much of the resistance to improved transportation and air pollution modeling practices in the past has come from the same parties that have most strongly resisted Clean Air Act implementation and that now seek to weaken or overturn its provisions requiring transportation plans and programs to contribute to air quality attainment. Inappropriate use of the models can be addressed by recognizing their shortcomings and expeditiously devising incremental improvements. **(3)** Rather than devoting adequate resources and methods to accomplish this, many state and regional transportation agencies prefer to question the requirements of the regulatory process, citing the small differences they find between "build/no-build" scenarios when these are analyzed using deeply flawed models.

The 1991 Intermodal Surface Transportation Efficiency Act (ISTEA) gave states unprecedented flexibility to use federal transportation capital assistance funds for planning, data collection, model development, and investments in different modes of travel. However, many states have been slow to flex funds from traditional highway construction to support improved performance measurement, modeling, and management systems. The CAA and ISTEA require a positive demonstration that transportation plans and programs contribute to public health and other goals, with the potential to cut off federal transportation funds to jurisdictions that fail to address persistent health-threatening air pollution problems related to motor vehicle use. Our scientific knowledge is more than adequate to support the CAA mandate that transportation spending be consistent with health-based air pollution control plans.

Despite its assertions to the contrary and statement that, "generalizations about the effects of added highway capacity on air quality could not be made with precision even with improved models," this TRB report concludes that, *"limiting highway capacity...is not likely to yield significant improvement in metropolitan air quality by current attainment deadlines."* Whether highway capacity will affect emissions over the 20 year life of transportation plans and for the duration of a region's maintenance period, as required by the CAA, is not judged. This TRB report strays from its assigned scope in implying that current regulations represent a collision of environmental goals and economic objectives likely to lead to delay and reassessment of environmental regulations, and to error and manipulation of the policy process (p. ES-11). The assertions of this TRB report's Conclusions ignore strong evidence that restraints on motor traffic growth can be highly supportive of economic development **(4)** and reveal the challenge that faces those who would defend the Clean Air Act's mandates for transportation planning. While this TRB report recommends "a more constructive approach" of adding new highway capacity, with congestion pricing to mitigate emissions growth, the report does not discuss the likely effects of restraining road capacity within a road pricing context. It is nonetheless arguable that higher motorist user fees and investments in public transportation and other alternatives would encourage earlier and greater energy and air pollution emissions reductions in a policy environment that limited, rather than accommodated, new highway capacity.

Minority Report Key Findings. The effects of added highway capacity on energy use and the environment are complex and vary over time. While we cannot determine with great precision the effect of an individual project, we can with some confidence determine the general direction and relative magnitude of changes that are likely to accompany substantially different investment programs and policies. We now know that trying to reduce emissions by emphasizing supply-side HOV and SOV highway capacity expansion strategies is at best uncertain and temporary. It often makes the problem worse by spurring greater motor vehicle travel demand and lower density automobile-dependent land use patterns, and by reducing the relative attractiveness of alternatives to automobile travel. While technological improvements to vehicles, fuels, and vehicle maintenance promise further cost-effective reductions in air pollution emissions, action is needed to manage the growth of traffic demand to reduce emissions of greenhouse gases and air pollution, curb noise pollution, manage traffic congestion, reduce dependence on foreign energy supply, boost the sustainability of our local and regional economies, and enhance community livability.

Limiting further highway capacity expansion, reducing highway capacity, and calming traffic (especially in central areas) can be effective strategies for reducing energy use, air pollution, and other environmental problems, particularly when done in a context of regional growth management that encourages revitalization of urban and suburban centers, rather than further sprawl. Smoothing traffic flows to reduce sharp acceleration and deceleration also offers significant promise for reducing emissions when done in the context of a balanced multi-modal transportation policy framework that includes effective demand management tools, such as road and parking pricing. Automated vehicle speed limitation using Intelligent Vehicle Highway Systems may also offer a promising future strategy and merits further investigation.

The best way to ensure that transportation plans and programs contribute to improved air quality is to ensure that they provide expanded opportunities to meet daily needs for access to jobs, shops, services, and recreation with less forced dependence on petroleum-fueled motor vehicles. This means promoting accessibility rather than mobility, using information and communications more effectively to manage community and mobility systems and to provide virtual access, and integrating land use and transportation planning and development with sound urban design for more livable, walkable, and efficient communities. It means explicating the hidden subsidies and tax expenditures that now spur inefficient consumption and investment patterns, charging motorists for these costs, and encouraging a new sense of values about transportation and the responsibilities of individuals in communities.

Much greater research, data collection, and model development is needed to support local and regional planning and policy evaluation and to better ascertain the effects of alternative investments and policies on energy use and the environment. This research, data collection, and development of decision-support systems should be undertaken as partnership involving local, regional, state, and federal agencies, within the ISTEA planning systems framework. The creativity and initiative of the private and non-profit sectors should be encouraged in developing these new management systems for sustainable regional economies and healthy communities. Special attention is needed to developing modal motor vehicle emission models and activity-based microsimulation models of travel behavior and surface transportation system performance. The federal government could play an important role by developing an information-based National Transportation System in cooperation with states and regions to strengthen strategic management systems for monitoring transportation system performance against key benchmarks, as well as the factors that affect travel demand and transportation service quality. These systems are needed to assure that transportation investments will contribute to wise expenditure of scarce taxpayer dollars, improved air quality, safety, and productivity, and more livable communities. Performance-oriented federal funding for transportation could also play a useful role.

Induced Traffic Effects: Findings from a Major UK Study

This TRB report's conclusions regarding induced traffic are an improvement over many earlier official studies, but are so heavily modified and hedged as to have little meaning. The recent British SACTRA study commission offers more useful guidance on the effect of major road projects (which it calls "schemes") and has far greater confidence than this TRB report in the ability of current scientific knowledge to evaluate these impacts. SACTRA found that, *"induced traffic is of greatest importance in the following circumstances:*

- *where the network is operating or is expected to operate close to capacity;*
- *where traveler responsiveness to changes in travel times or costs is high, as may occur where trips are suppressed by congestion and then released when the network is improved;*
- *where the implementation of a scheme causes large changes in travel costs.*"

This suggests that the categories of road where appraisal needs to be most careful are improvements to roads in and around urban areas, estuary crossing schemes, and strategic capacity-enhancing interurban schemes, including motorway widening...[Studies] we have reviewed demonstrate convincingly that the economic value of a scheme can be overestimated by the omission of even a small amount of induced traffic. We recommend that variable demand methods should now become the normal basis of trunk road forecasts, and these forecasts must be carried through into the operational, economic, and environmental evaluation of schemes in a systematic way. In particular, where networks are operating close to capacity, suitable procedures must be used to represent the constraint of traffic in the base case and the release of traffic growth in the do-something case as additional capacity is provided...We do not think that continuing to appraise solely at the scheme level using the fixed demand approach is, either intellectually, or in practical terms, acceptable. It is this central conclusion which has led us to make the recommendations in this Report" (p. iii-iv)

"Results of published research demonstrate the following important findings, to a reasonable level of confidence: (a) there is an effect of fuel prices on traffic levels, and a larger effect on fuel consumption; (b) the quality and/or price of public transport can have a small effect on car ownership or use, or perhaps both; (c) the length of the motorway network is one of the influences on the amount of traffic using it; (d) some but not all of the time saved on travel when journey speed increases is likely to be used for additional travel; (e) car users do in fact trade-off time and money to an extent and a measure of this trade-off is given by the empirical estimation of the value of time savings; (f) journey times can have an influence on depot location and length of haul of freight operations; (g) the land-use changes consequent on improved access are likely, in turn, to lead to changes in the patterns of travel, car dependence, and the volume of travel." (p. 45) SACTRA concluded that in the short-term, *"about*

half the time saved through speed increases might be used for additional travel...the longer-term effect is likely to be greater, with a higher proportion (perhaps all) of the time saved being used for further travel." (p. 47)

These conclusions are more comprehensive and succinct than this TRB report and differ in some key respects, particularly with regard to the potential impact of highway expansion on freight travel, the elasticity of travel demand with respect to time savings, and the prospects for improving plan and project appraisal. It is the position of this minority report that SACTRA has better stated the current state of scientific knowledge in this area. The "fixed demand" approach (i.e. assuming that building new highway capacity will have no effect on land use and time-of-day of travel or other components of travel demand), which SACTRA finds unacceptable, is the same approach that in the U.S. produces differences between scenarios smaller that than the error term of the models, of which this TRB report is critical. SACTRA prescribes the use of now available improved analytical methods for project appraisal, rather than questioning our ability to perform such analysis to meet regulatory requirements.

Determinants of Travel Demand

Effects of Subsidies. This TRB report implies that growth in traffic is an inevitable function of income and economic growth (Chapter 4) and indeed these are important factors in traffic growth. However, this TRB report generally avoids discussing the effects of hidden subsidies and transport pricing systems in explaining the growth of motor vehicle use, although these too are key determinants that reinforce automobile dependent lifestyles, consumption trends, and land use patterns. In the U.S. a major share of the costs of highway construction and maintenance continues to be paid for out of general tax revenues, mostly at the local government level. The large past investment in highway capacity by taxpayers imposes a stream of current and future costs which affect the provision of added capacity.

The recent report by the U.S. Congressional Office of Technology Assessment (OTA), *Saving Energy in Transportation*, July 1994, provides a good accounting of these elements (pp. 91-111). OTA identifies $76.5 billion in 1990 public spending on highway construction, maintenance and services covered by payments by motor vehicle users, along with hidden private sector expenditures related to motor vehicle use of $150 to $400 billion a year in 1990 for parking. OTA estimates that U.S. taxpayers provided $33 to $64 billion in subsidies for highway construction and motor vehicle infrastructure and services in 1990, after accounting for total costs and deducting payments by motor vehicle users. Non-monetary externality costs related to motor vehicle use are estimated at $325-580 billion per year in 1990. According to OTA, *"Approximately 49 to 61 percent of the total monetary and nonmonetary costs of motor vehicle use, excluding the value of time, are efficiently priced [i.e. paid and recognized by motor vehicle users]*" (p.109-110). M*otor vehicle users paid openly for 53 to 69 percent of the social (public plus private) costs of motor vehicle use, both monetary and non-monetary, excluding the value of time...if subsidies were withdrawn, externalities 'internalized,' and hidden costs brought out into the open and directly charged to motor vehicle users, the perceived costs of motor vehicle use would increase substantially (by 14 to 89 percent, depending on whether nonmonetary costs and other factors are included), and people would drive less.* Such factors play a major role in influencing the effects of highway capacity changes on energy and the environment, as this TRB report implies in its closing discussion of "managed capacity" strategies.

Effects of Added Highway Capacity on Freight Travel Demand. The Royal Commission on Environmental Pollution, in their 1994 *Transport and the Environment* report (p.166), states, "it is clear that where an alternative is available, moving freight by road takes more space, uses more energy, produces, more pollution, and is more likely to lead to an accident." The short-term potential to switch freight from road to rail, water, or pipeline transportation is limited by the specialized functional requirements for many types of shipments, as this TRB report correctly notes. However, over a period of two or more decades, alternative transportation investment choices could produce profound differences in freight travel demand. Contrast, for example, a program of significant further public investment in freeway capacity expansion vs. a program of minor highway capacity expansion, conversion of existing HOV and SOV freeway lanes to privately managed toll facilities, combined with policies promoting more aggressive private development of intermodal transfer facilities, railways, water and pipeline based freight systems, and intelligent intermodal freight management systems. Clearly, highway capacity expansion will affect the use of just-in-time shipping, and in the longer term, the location of commercial, warehouse, and industrial activities.

Effects of Added Highway Capacity in Built-Up Areas. This TRB report asserts that *"within developed areas, traffic flow improvements such as better traffic signal timing and left turn lanes that alleviate bottlenecks may reduce some emissions and energy use by reducing speed variation and smoothing traffic flows without risking large offsetting increases from new development and related traffic growth."* Elsewhere, (p.6-25), the report states, *"Capacity enhancement measures in central cities and other built up areas are less likely to experience...longer-term impacts [of stimulated travel demand] because there is limited potential for development."* While small capacity expanding projects individually may have positive short-term effects on emissions, when many such projects are combined, the effects on latent traffic generation are likely to be significant, as this TRB report acknowledges.

Alleviating bottlenecks with new highway capacity frequently leads to the greatest release of latent or suppressed travel demand, especially in more densely developed areas. There are many cases where traffic flow improvements are taken at the expense of pedestrians, bicyclists, and users of public transportation. These investments often make it more dangerous to travel in the community except by motor vehicle or these investments represent lost opportunities to restore a walkable streetscape and near-road environment. In many older urban and town centers, such "improvements" have contributed to the decline of old shopping districts, which have lost their amenity and charm, often sacrificing traffic slowing and pedestrian-enhancing on-street parking in the interests of faster and greater traffic throughput to spur the driver on to the nearby shopping mall, where pedestrian space is privatized and controlled, and accessible only by car. Areawide traffic signal control systems that significantly boost average travel speeds across many streets and corridors can spur induced traffic and thus may more than fully offset any short-term emission reductions due to traffic smoothing and speed change effects unless accompanied by effective and ongoing travel demand management programs, such as pricing, parking management, and street-space reallocation for transit and non-motorized travelers.

Consideration of Alternatives to Highway Capacity Expansion. Consideration of alternative scenarios is vital to answering the question, "What is the effect of added highway capacity on energy use and the environment?" Alternatives will produce different patterns of travel demand and transportation system performance, emissions, and energy use. This TRB report's discussion of the consequences of alternative scenarios (p. 6-26 and 6-27), however, focuses mostly alternatives that expand transportation system supply. The key example given assumes that demand and congestion will inevitably grow without considering the potential for demand management strategies. There are many ways of reallocating investment, street-space, subsidies, and land activities and reshaping urban design and pricing systems -- it is not just a choice of highway investment or transit investment.

Portland. A major foundation and FHWA-sponsored study, "Making the Land Use Transportation Air Quality Connection," (LUTRAQ) considered this question by evaluating a proposed Western Bypass highway around the west side of Portland, Oregon, vs. a transit and pedestrian oriented development alternative. The lessons from LUTRAQ are that transit and pedestrian oriented urban design and infill development and the retrofit of pedestrian improvements to automobile-oriented suburbs can have significant effects on travel behavior sufficient to eliminate the need to build new ring freeways, particularly when reinforced by sensible economic and pricing incentives, such as modest parking charges and reduced transit fares that begin to level the playing field between travel modes. Total vehicle trips per household in the TODs were 6.05 per day, compared to 7.09 outside the TODs under the LUTRAQ scenario and 7.7 with either the Bypass or No Action alternative. The LUTRAQ scenario reduced VMT in the study area by almost 14% compared with the Bypass alternative and reduced Vehicle Hours of Travel in the PM peak hour by almost 8%. Even greater effects on travel behavior can be expected when these measures are combined with bicycle improvements, stronger economic incentives, more effective parking management, introduction of neighborhood vehicles, and further shifts in land use policies to favor infill housing and commercial development.

This TRB report discusses, but misreads, the LUTRAQ study (p.5.32-35), and is likely to mislead the reader. Instead of presenting data on travel demand changes in the specific areas subject to policy intervention, the TRB report cites regional data in which the effects of policy interventions are much diluted. Instead of presenting data on total travel or non-work travel which composes the vast majority of all trips, the TRB report draws its conclusions principally from changes estimated for work trips. Thus, the TRB report incorrectly states that "the travel demand measures [employee commuter subsidy programs that support transit and charge for parking] increase both transit use and carpooling more than the land use and design measures." In fact, the LUTRAQ analysis indicated these TDM measures accounted for only about 30% of the increase in non-automobile driver mode shares for all trips and about 55% of the increase in non-automobile work trip mode shares, not counting the corrections for underestimated walk trips, which would further increase the effects of the design measures. **(5)**

The LUTRAQ model incorporated measures of pedestrian friendliness but underestimated the potential to shift short car trips to pedestrian trips. This was due to acknowledged under-reporting of walk trips in the 1985 Portland household travel survey data, **(6)** the assumption that nowhere in the region would pedestrian friendliness be better than it is today in downtown Portland, and the insensitivity of the pedestrian mode choice model to pricing and other TDM measures. Clearly, Portland neighborhoods could become far more pedestrian friendly than observed today. Market-based pricing strategies and other TDM would also increase the propensity to satisfy travel needs by walking and bicycling. Despite these shortcomings, the LUTRAQ analysis showed that modest improvement in the quality of the pedestrian environment alone could reduce the Vehicle Miles of Travel in suburban zones by about 10%. Variation in building orientation at the zonal level was also found to account for changes of 10% or more in VMT per household. **(7)**

Key LUTRAQ performance measures cited in this TRB report (Table 5-5) do not reflect adjustments made by Cambridge Systematics to correct for known under-sampling of pedestrian trips in the 1985 Portland travel survey. Data on travel demand changes estimated for the much larger study region is emphasized, rather than the significant travel demand reduction effects noted in relation to Transit Oriented Developments (TODs) vs. conventional highway-oriented development. LUTRAQ did not attempt to modify urban design patterns in the entire study area, but only in selected neighborhoods near new transit lines. The LUTRAQ assumptions for the composition and mix of building types for development was also constrained by a market demand forecast that assumed the housing preferences of recent decades for different demographic segments would persist into the future, which implies continued tax subsidies for housing and automobile transportation, rising real household incomes, and continued high levels of consumer and public debt to finance housing and transportation consumption. Moreover, the LUTRAQ model was unable to reflect potential improvement of bicycle friendliness, bicycle access to transit, or encouraging bicycle use, due to the lack of available local empirical data. However, experience in cities such as Davis, California, and Copenhagen, Denmark, show that reallocation of street space and development of comprehensive cycling networks can have a profound effect in diverting car trips to the bicycle and that bicycle access can promote dramatic expansion of transit catchment areas. **(8)** Indeed, the Portland regional government (Metro) is moving forward to develop methods for incorporating these additional factors into their long range planning analyses.

London. Portland, Oregon, is being joined by a growing number of other regions considering such alternatives. A study by the UK Department of Transport for the greater London region found that a combination of car restraint and improved public transport -- with a cordon charge, reduced parking provision and light rail construction -- would likely reduce carbon dioxide emissions by 23% compared with the base case for 2000. It was estimated that this combined strategy would reduce traffic entering the central area of London and increase peak period traffic speeds in the central area from 23 to 30 km/h. About 15% of this increase was projected to be due to the effects of the light rail network and the remainder due to measures to restrain traffic. **(9)**

Copenhagen. Some regions have made these kinds of changes real. In Copenhagen, a city of 1.7 million people, road building was abandoned in the early 1970s, large numbers of bus priority lanes were introduced, and a comprehensive network of segregated cycle paths built. The result was a 10% fall in traffic since 1970 and an 80% increase in the use of bicycles since 1980. About one-third of commuters now use cars, one-third public transport, and one-third bicycles. Cycling accidents have decreased slightly, despite the increase in mileage, because of the network of cycle paths, which in many cases were created by reallocating arterial street space from cars. **(10)** Had Copenhagen embarked on major highway expansions in recent decades, surely energy use and emissions would be far higher than they are today. Is this not relevant evidence that highway capacity expansion in metropolitan areas promotes environmental degradation?

Effect of Reduced Highway Speed and Capacity

Since the 1970s in Europe, Japan, Australia, and increasingly in the U.S., traffic calming and traffic cell systems are being developed to reduce traffic speed and capacity in central areas as well as residential neighborhoods. There is empirical evidence that these highway capacity reduction strategies typically also reduce air pollution emissions, noise, and energy use. Although mentioned in this TRB report (p. 3-12), this evidence is not well considered in the report's findings.

Reducing Road Speed and Capacity with Traffic Calming. Traffic calming encompasses a wide range of techniques for slowing down motor vehicle traffic to provide an environment more supportive of walking and bicycling and safer for children, the elderly, and others. Traffic calming measures include narrowing roadways, reducing speed limits, introducing curvilinear elements in formerly straight street to slow traffic, and changing the vertical profile of the street with elements such as raised intersection tables for pedestrian and bicycle path crossings. Although the EPA MOBILE model would indicate that slowing down traffic typically increases emissions, empirical research indicates the opposite in many cases. Research in Germany has shown that the greater the speed of vehicles in built-up areas, the higher is the incidence of acceleration, deceleration and braking, all of which increase air pollution. German research indicates that traffic calming reduces idle times by 15%, gear changing by 12%, brake use by 14%, and gasoline use by 12%. **(11)** This slower and calmer style of driving reduces emissions, as demonstrated by an evaluation in Buxtehude, Germany. The table below shows the relative change in emissions and fuel use when the speed limit is cut from 50 km/h (30 mph) to 30 km/h (20 mph), for two different driving styles. Even aggressive driving under the slower speed limit produces lower emissions (but higher fuel use) than under the higher speed limit, although calm driving produces greater reductions for most emissions and net fuel savings. **(12)**

Change in Vehicle Emissions and Fuel Use with Speed
Change from 50 km/h to 30 km/h

Emission Type	Driving Style 2nd Gear Aggressive	 3rd Gear Calm
CO	-17%	-13%
HC	-10%	-22%
NOx	-32%	-48%
Fuel Use	+7%	-7%

Moreover, by encouraging more use of walking and bicycling and reducing the advantage offered by the automobile for short trips relative to these alternatives, traffic calming usually reduces the number of trips, trip starts, and VMT. Applied on a widespread basis in conjunction with transit improvements and transportation pricing changes, traffic calming may contribute as well to a reduction in household automobile ownership levels, further reducing emissions and travel demand. Thus, even in circumstances where individual vehicle emissions per mile traveled increase due to more aggressive acceleration, braking, and use of second gear, traffic calming will likely lead to overall emission reductions due to its influence on travel demand.

A recent FHWA report discusses the German experience with traffic calming in six cities and towns in the early 1980s: *"The initial reports showed that with a reduction of speed from 37 km/h (23 mph) to 20 km/h (12 mph), traffic volume remained constant, but there was a 60% decrease in injuries, and a 43% to 53% reduction in fatalities. Air pollution decreased between 10% and 50%. The German Auto Club, skeptical of the official results, did their own research which showed broad acceptance after initial opposition by the motorists. Interviews of residents and motorists in the traffic calmed areas showed that the percentage of motorists who considered a 30 km/h (18 mph) speed limit acceptable grew from 27% before implementation to 67% after implementation, while the percentage of receptive residents grew from 30% to 75%.*" **(13)** This experience of initial skepticism of traffic calming, followed by its widespread popularity after implementation, has been experienced in hundreds of communities across Europe, Japan, and Australia, along with the few U.S. communities which have adopted such strategies, such as Palo Alto, California, and Seattle, Washington.

Reducing Road Capacity with Traffic Cells for Environmental Benefit. Many places in Europe and Japan -- from cities like Göteborg, Sweden and Hannover Germany to Osaka, Japan, from suburban new towns such as Houten, Netherlands, to established automobile-oriented suburban centers like Davis, California -- have successfully implemented traffic cell systems. These typically consist of a set of radial pedestrian, bicycle, and transit-only streets focused on a central area. While pedestrians, bicyclists, and public transportation can freely cross these streets, automobile traffic cannot, but must instead use a ring road around the center. Traffic cell systems are very effective at eliminating through traffic in central areas and shifting short automobile trips in the central area to walking, bicycling, and public transportation, significantly reducing cold start and evaporative emissions. By reducing central area traffic and increasing street space dedicated to walking, bicycling, and public transportation, these alternatives become more attractive and parking requirements in the central area diminish. Success in reducing environmental impacts is dependent on curbing automobile-oriented peripheral development.

Göteborg, Sweden, introduced traffic cells in mid-1970s together with priority for public transport at signals, new suburb-to-downtown express bus service, and central area parking controls. Traffic accidents were reduced 36%, noise was cut from 74 to 67 dB in the main shopping street, peak CO levels dropped 9%, 17% fewer cars entered the center city, weekday transit trips to the center were up 6%, traffic on the inner ring road was up 25%, and the costs of running public transport went down 2%. Nagoya, Japan, introduced traffic cells in residential areas in the mid 1970s, together with computer managed signal system, bus lanes, bus priority at signals, staggered work hours, and parking regulation. This resulted in a 17% increase in traffic speeds on main roads covered by the signal system, a 3% increase in bus ridership. Traffic deaths in traffic cell areas fell 58%, 15% fewer cars entered the central area in the morning peak, and auto-related air pollution decreased by 16%. **(14)**

The Downtown Crossing pedestrian zone, in Boston, Massachusetts, is a limited traffic cell serving a core area with 125,000 employees. Eleven blocks of the central business district were closed to traffic in 1978, while steps were taken to improve transit service and parking management. In the first year, there was a 5% increase in visitors to the area, a 19% increase in weekday shop purchases, a 30% increase in weeknight purchases, an 11% increase in Saturday purchases, a 21% increase in walking trips to the area, a 6% increase in transit trips to the area, a 38% decrease in auto trips to the area, and no increase in traffic congestion on adjacent streets, thanks to elimination of on-street parking and stricter parking enforcement on nearby traffic streets.

Davis, California, a town of 50,000 people near Sacramento, illustrates a successful full traffic cell system which has cut highway capacity significantly in the vicinity of the University of California and town center to increase walk and bicycle use. Bicycle use grew sharply in the 1960s, leading to election of a pro-bikeway City Council in 1966. Demonstration bikelanes proved popular and were quickly extended. In addition to the UC Davis traffic cell and bicycle network, the City of Davis now has 37 miles of bicycle lanes and 29 miles of bicycle paths in an interconnected network. Parking is limited and costs drivers on the UC Davis campus. Bus, van, and commuter rail services offer other alternatives to the automobile. Davis has prohibited development of shopping centers near the freeway, retaining a vibrant pedestrian-oriented downtown commercial area. As a result, 27% of UC Davis employees and 53% of UC Davis student use bicycles as their primary commute mode, of those who live and work in Davis, 44% bicycle to work. The City Planning Department estimates that 25% of all person trips in the city are by bicycle. Walk shares in the city are also high -- on the order of 10-20%. Clearly air pollution has been reduced by restricting and reducing highway capacity in Davis.

Effect of Highway Capacity Additions on Metropolitan Form

This TRB report is correct that, *"major highway capacity additions in less well developed parts of rapidly growing metropolitan areas pose a greater risk of increasing emission levels and energy use in those areas. Emissions and energy use may be reduced initially if the capacity addition alleviates congestion. However, if developable land is available and other growth conditions are present, new capacity is likely to steer development and related traffic to the location of the improvement, with* *corresponding increases in emission levels and energy use in these areas"* (p. 6-27). Yet the TRB report notes, "*it may be years before changes in land use and related traffic patterns make a significant difference in regional emission levels and air quality,*" (p.ES-10) downplaying this potential effect in relation to conformity analysis by following with the statement, *"In comparison, implementation of CAAA-required vehicular and fuel standards and enhanced vehicle inspection and maintenance programs, combined with fleet turnover, is estimated to reduce emissions of major pollutants by one quarter to one third by attainment deadlines. Market-based TCMs--increased parking charges, time-of-day tolls--also have greater potential for emission reductions..."*

Most new highway development is likely to have a significant emission increasing effect within the 20 year planning horizon for conformity analysis unless the region is experiencing no net economic growth or the region's highway-access-dependent periphery is not growing at the expense of its older urban neighborhoods. It is irrelevant whether the highway expansion redistributes growth that would have occurred elsewhere in the region or whether it stimulates productivity gains that result in new growth (p. ES-9). Most new highway capacity will eventually foster automobile-oriented growth. In either case, increased emissions may break an emissions budget and work against attainment and maintenance of health standards.

In regions undergoing rapid development and significant infrastructure investment, major regional impacts on motor vehicle emissions have been observed in relatively short time horizons. Substantial economic growth has not always been accompanied by proportional growth in traffic. Restrained investment in highways accompanied by enhancements of pedestrian, bicycle, and transit access, economic incentives encouraging alternatives to the automobile, and supportive land use policies have resulted in slower growth of traffic despite rising motorization and dramatic economic growth in many European and Asian metropolitan areas, most notably in cities such as Copenhagen, the Randstadt (Amsterdam-Hague-Rotterdam-Utrecht, Netherlands), and in Japanese and Chinese cities. Indeed, there is evidence that such policies enhance growth and economic development. **(15)**

This evidence is given no mention in the committee report, which instead emphasizes that accessibility and generalized travel cost changes are only one factor shaping metropolitan development. However, the committee's report appears to overgeneralize its conclusions regarding the 20-year effects of highway capacity changes on land use patterns, drawing evidence primarily from land use model projections that can be called into question. For example, the committee report discusses the relatively small changes (plus or minus a few percentage points) in region-wide locations of employment and households in built-up metropolitan areas over a 20-year forecast period from system wide changes in travel time of as much as 20 percent, predicted using commercially available, but less-than-state-of-the-art land use models. This is cited as evidence that added highway capacity will have small impacts on regional air quality. However, the land use models cited have usually been calibrated on very short time-series data, often 1980-85 or 1985-90, when substantial "hot" S&L money was diverted into highly speculative and often non-economically-viable real estate development. The models used in the U.S. have mostly failed to represent land and rent values, the variable quality of key public services (education, public safety), and the potential for mix-used cluster development around nodes of high public transportation accessibility. Moreover, the results of model evaluations have usually been predicated on exogenous constraints related to zoning and limitation of redevelopment, giving little room for differences between transportation investment scenarios to express themselves.

In short, the SACTRA report offers more effective statements of our current state of knowledge in these matters, indicating that added highway capacity indeed frequently leads to changes in development patterns that reinforce motor vehicle dependence and use.

Data Collection, Model Development, and Research Needs

There is broad agreement with this TRB report's conclusions regarding need for improved emission and travel related data collection and model development. Cost-effective resolution of some of the central questions posed by this TRB study would be well supported by a cooperative effort of states, local governments, and regions, with federal leadership, to develop broader standards for traffic and travel data collection, the coding of networks and spatial databases, and transportation/land use monitoring and performance measurement systems. Dozens of uncoordinated, incompatible data systems now hinder development of effective benchmarks and comparative evaluation frameworks for local and national strategic planning as well as theoretical research. Externality costs of transportation and land use investments, such as hidden subsidies, pollution and congestion costs, accident and health effects, need to be more widely appraised through local measurement and monitoring. A national household travel panel survey is needed to better comprehend the dynamics of travel and activity patterns, vehicle acquisition and use, residential location choice, and commercial development. States should be encouraged to allocate an increased share of surface transportation capital resources to system management and monitoring, planning, and forecasting, to promote long-term, least-cost strategies for community and regional development. The alternative is to continue to pursue costly taxpayer-subsidized, pork-barrel spending unsuited to an era demanding lean government.

The Build/No-Build Test and Regulatory Backlash

New Scientific Uncertainty or Just a New Backlash? This TRB report challenges the "build/no-build" test that has been a key part of transportation conformity under the federal Clean Air Act. This challenge would respond to the distress expressed by many individuals involved in highway development to the November 1993 final EPA transportation conformity rule. Supporters of highway development were generally satisfied with the science of emission speed factor adjustments during the era of EPA's interim conformity rule 1991-93 and under earlier versions of conformity. During this era, the conformity rule and the emission speed factor adjustments worked together to assure that new road capacity would be found to increase average motor vehicle travel speeds and reduce vehicle miles traveled and hence reduce air pollution emissions (of Carbon Monoxide (CO) and Volatile Organic Compounds (VOC)), at least by a slight amount (based on EPA's official models), thus sustaining business as usual. However, in 1994, with the final transportation conformity rule, the build/no-build test was extended to also apply to Nitrogen Oxides (NOx). NOx generally increases with higher engine speed and efficiency of combustion, thus rising with the higher traffic speeds that usually accompany highway capacity expansion (based on EPA's official models). The final rule thus questioned the wisdom of massive road expansion especially in areas where NOx controls will be needed to reduce ozone problems. Only now, when emission speed adjustment factors in EPA's emission model have regulatory implications for the addition of new high speed roadway capacity, are major issues being raised about their scientific basis. There were few complaints when transportation plans passed the test by less than a fraction of 1%. Now there is a widespread outcry over transportation plans failing the test by equivalent amounts, although most agencies doing modeling have thus far been able to get around these problems with "just-in-time model enhancements" and the addition of mitigation TDM programs.

Now, as this TRB report states about the effects of added highway capacity on the environment and energy use, "*no definitive and comprehensive conclusions can be reached...the conformity test will change as the build no build test is phased out...*" Indeed, proposals have been introduced in the new Congress to repeal part or all of the CAA, including transportation conformity, as well as to the existing provisions under the CAA that allow states to avoid the build/no-build test as soon as they submit acceptable plans (SIPs) for attaining healthy air quality. Under current regulations, however, with acceptable SIPs, states only need to show that their transportation plan produces emissions less than the emission budget they have adopted for transportation. A challenge to the way EPA's build/no-build test has been applied by regional agencies may be deserved. However, millions of Americans with serious respiratory problems that are worsened by motor-vehicle related air pollution breath unhealthful air 25 years after the first Clean Air Act despite cleaner tailpipes and significant but inadequate progress towards attainment. Our science is adequate to tell us that large-scale highway expansion, even with congestion pricing on new facilities, will not contribute to attainment and maintenance of healthful air compared to alternative investments and policies. This TRB report has gone too far in asserting scientific uncertainty.

The Real Problems With Build/No-Build. As typically applied, the build/no-build test assumes that building major new highways will have no effect on land use patterns, time-of-day-of-travel, and often even travel mode or choice of destinations. This is the "fixed demand" approach to analysis decried by SACTRA. A computer simulation is performed that assumes a fixed pattern of vehicle trip-making in a region and two alternative transportation networks -- the region's road system with and without a set of road improvements. The predictable result is that the computer simulation shows that adding lanes or new roads will alleviate congestion, provide shorter faster travel routes, and reduce the number of miles of driving compared to not building the improvements. Average travel speeds will go up at least slightly with the improvements. And if one believes the speed adjustment factors of EPA's MOBILE emissions model, with the road improvements, VOC and CO emissions will go down and NOx emissions will go up, in most cases by much less than one percent. It is predictable that most agencies have found "*microscopic differences between the two cases, implying a level of precision well beyond the analytical capability of the models*." (Hartgen, 1994)

Highlight Near-Term Model Reform Needs. Indeed, most transportation models in use are little changed in architecture or policy sensitivity from the 1970s and 80s and are generally designed to overestimate the benefits of both highway and transit investment. They ignore urban design, walking and bicycling, hidden transportation subsidies and user costs, the way people plan trip itineraries and make decisions about travel and vehicle use, and the time of day of travel effects. While some agencies have made improvements to travel models in the past several years on their own, many more have moved only slowly in response to pressure from local and national environmental groups or federal agencies. A few agencies are expeditiously moving toward best practices in the field, such as Portland, Oregon, which is undertaking new activity based surveys, stated preference surveys, and development of yet more policy-sensitive analysis tools.

This TRB report might have highlighted the short- and mid-term fixes available to support better conformity analysis. Good discrete choice models, based on recent surveys, including total personal travel rather than just motor vehicle trips, with formal or informal accounting for the effects of highway capacity increases on land development, time-of-day-of-travel, mode and destination choice can be developed in any metropolitan area in the span of a year or two year with an investment costing a fraction of the cost of a single freeway interchange. Such "better practices" analysis tools can be used to perform far more policy-sensitive build/no-build tests in the near term, which will not be highly accurate or certain, but at least will be more likely to point in the right direction than current analyses. The state-of-the-art of modeling is advancing rapidly in this area, and data collection and research is warranted today for most metropolitan transportation planning agencies to prepare for the next generation of microsimulation-based analysis tools. The SACTRA panel offers useful recommendations for modeling and analysis, including issuance of general advice on good practice in developing models, the auditing of strategic transport demand models to assure their satisfactory sensitivity "*to estimate all the important demand responses to road provision, including trip frequency and choice of time of travel.*" (p. 191)

Emission models are in critical need of redevelopment with support for research at the national level. Recent EPA and California Air Resources Board (CARB) research shows that the federal test procedure and other drive-cycle based emission estimation approaches do not well match current driving conditions. Significant variability exists in emissions between vehicles undergoing similar speed changes and in the same vehicle under different load conditions. There is consensus within the committee that modal based emissions models need to be developed to improve the evaluation of the effects of changes in speed, acceleration, and traffic system management, such as Intelligent Vehicle Highway Systems (IVHS) and some work is underway, but could be accelerated. As this TRB report notes, "current models significantly underpredict emissions of some pollutants (p. ES-8)." This is yet further reason to place greater emphasis on the analysis of emissions impacts of growth in travel demand likely to be induced by highway investment rather than continuing to focus analysis solely or primarily on the analysis of emissions impacts related to harder to estimate changes in vehicle speeds that are modified by highway investments.

Performance-based funding that gives states flexibility in expending federal funds contingent on meeting key objectives is in place under the CAA and ISTEA with the transportation conformity and management system requirements. While evaluation tools like MOBILE 5.1 are imperfect, they should continue to be used with caution as the best analysis models currently available to support ongoing public policy making. When needed, ad hoc project-specific methods should be used to complement these tools until better data and software is available. Sound transportation and environmental policy-making should focus air pollution control strategies on cost-effective technological controls, such as inspection and maintenance of vehicles and reformulated gasoline, as well as strategies that reduce the growth in vehicle trip starts, vehicle miles of travel, and motor vehicle dependence. Until we get our emission models more refined, we should focus less on strategies that depend on demonstrating emission reductions on the basis of changes in traffic speed. We should not abandon the analysis of the emissions impacts of alternative transportation investments and policies because of uncertainties about emission changes with respect to speed, accelerations, and other factors. We should improve the quality of performance measurement, analysis, and forecasting systems and expand the range of alternatives considered in the evolving new regional transportation planning process.

References

(1) Standing Advisory Committee on Trunk Road Assessment, *Trunk Roads and the Generation of Traffic*, Department of Transport, HMSO, London, December 1994 (ISBN 011- 551613-1, order by telephone: 011-33-171-873-9090, £24)

(2) The Royal Commission on Environmental Pollution, *Transport and the Environment*, HMSO, London, October 1994, Cm 2674 (£25.60)

(3) Michael Replogle, *Improving Transportation Models for Air Quality and Long Range Planning*, Presented at Transportation Research Board Annual Meeting, January 1993, Environmental Defense Fund, Washington, DC.; Cambridge Systematics, *Short-Term Travel Model Improvements*, Federal Highway Administration, Washington, DC, 1994; Greig Harvey, *A Manual of Improved Modeling Practice,* EPA Region IX, Sacramento, CA, 1993; *Declaration of Dr. Peter R. Stopher in Support of Sierra Club's Objections to MTC's Proposed Conformity Assessment*, Sierra Club vs. Metropolitan Transportation Commission, et al., U.S. District Court for the Northern District of California, September 1988, San Francisco, California.

(4) Walter Hook and Michael Replogle, "Motorization and Non-Motorized Transportation in Asia: Transport System Evolution in China, Japan, and Indonesia," *Land Use Policy*, October 1995 (forthcoming);

(5) Correspondence from Thomas Rossi, Cambridge Systematics, to Michael Replogle, EDF, February 8, 1995, and project LUTRAQ work papers, summer 1992.

(6) Cambridge Systematics, Inc., et.al., *The LUTRAQ Alternative/Analysis of Alternatives: Interim Report*, 1000 Friends of Oregon, Portland, OR, October 1992, p.82, 97-101.

(7) Parsons Brinckerhoff Quade and Douglas, Inc., *Making the Land Use Transportation Air Quality Connection: Vol. 4B, Building Orientation*, 1000 Friends of Oregon, Portland, OR, May 1994.

(8) Michael Replogle, *Bicycle and Pedestrian Policies and Programs in Asia, Australia, and New Zealand,* Federal Highway Administration, 1993, Washington, DC. and Michael Replogle, *Transportation Conformity and Demand Management: Vital Strategies for Air Quality Attainment*, Environmental Defense Fund, 1994, Washington, DC., and Michael Replogle and Harriet Parcells, *Improving Bicycle/Pedestrian Linkage to Transit, Federal Highway Administration*, 1993, Washington, DC.

(9) Royal Commission on Environmental Pollution, p. 194.

(10) Royal Commission on Environmental Pollution, op.cit, p.195.

(11) Peter Newman and Jeff Kenworthy, *Winning Back the Cities,* Pluto Press, Leichhardt NSW, Australia, 1992, p.39-40. citing C. Hass-Klau, editor, *New Ways of Managing Traffic* (title of issue), *Built Environment,* 12 (1/2). 1986.)

(12) Peter Newman and Jeff Kenworthy, *Winning Back the Cities,* Pluto Press, Leichhardt NSW, Australia, 1992, p.39-40. citing T. Pharoah and J. Russell, *Traffic Calming: Policy Evaluation in Three European Countries*, Occasional Paper 2/89, Department of Planning, Housing, and Development, South Bank Polytechnic, London.

(13) Project for Public Spaces, *The Effects of Environmental Design on the Amount and Type of Bicycling and Walking,* National Bicycling and Walking Study, Federal Highway Administration, October 1992, Washington, DC, p.15. citing CART, *Traffic Calming,* Ashgrove, Australia, CART, 1989

(14) U.S. National League of Cities, *Transportation and the Urban Environment*, Washington, DC, 1979, p.32.

(15) Michael Replogle, Sustainability: A Vital Concept for Transportation Planning and Development," *Journal of Advanced Transportation*, vol.25, no.1, Spring 1991, p.3-18.